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Use of Bromadiolone for the Control of the Columbian Ground Squirrel

By

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ABSTRACT

A field trial was conducted to test the efficacy of a single-dose application of bromadiolone treated squirreled oat groats on Columbian ground squirrels in western Montana. The bromadiolone bait (100 ppm) was scattered by hand at a rate of 9 g per burrow opening. The mortality of radio-tagged squirrels was 94.1 percent. The percent of radio-tagged squirrels that died above ground was 35.3 percent and the average time between bait application and death was 5.5 days. Carcasses were recovered for analysis of bromadiolone residues. Movements of radio-tagged squirrels before death showed male squirrels had a much larger home range than female squirrels.

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INTRODUCTION

Application of rodenticide baits is a common method used for the control of rodents such as ground squirrels that damage agricultural crops. For the control of the Columbian ground squirrel (Spermophilus columbianus) in western Montana there is not presently a registered rodenticide that is effective and economical on large acreages. Compound 1080 has been the most efficacious rodenticide but is no longer registered as a field rodenticide in Montana. Strychnine is currently registered for ground squirrels but has a consistent history of poor efficacy on the Columbian ground squirrel. Other control methods such as anticoagulant rodenticides in bait stations, burrow fumigants and trapping are efficacious but uneconomical for use on large acreages. For these reasons studies on potential rodenticide materials that are efficacious and economical on large acreages are needed.

Bromadiolone is an effective rodenticide against Columbian ground squirrels when placed in bait stations (Sullivan 1982a) and when presented in single dose applications (Sullivan 1982b, 1983). Further studies using bromadiolone baits were conducted to determine efficacy at a lower active ingredient concentration than previously evaluated in Montana.

OBJECTIVES

1. Determine the efficacy of 100 ppm (0.01%) bromadiolone bait for the Columbian ground squirrel.

2. Determine the percentage of animals dying above and below ground.

3. Determine the time between bait application and death of ground squirrels.

4. Recover ground squirrel carcasses for analysis of bromadiolone residues.

METHODS

Study Site - The study site was located in Lewis and Clark County, Montana. A Columbian ground squirrel colony of moderate to high squirrel density covering 3.6 acres was selected. The site was an isolated, narrow strip of land located between an interstate highway and a local frontage road. The area was a dryland, noncrop site that was occassionally used a pasture.

Test Bait - The test bait was formulated using squirreled oat groats (hulled, slightly rolled) as the carrier. The bromadiolone concentration was 100 ppm (0.01%).

Time of Baiting - Bait was applied July 1, 1987, approximately four weeks after the young-of-the-year emerged from their natal burrows. Plants on the study site were producing seeds and the squirrels were readily accepting grains.

Method of Bait Application - Bait was spot baited by hand using calibrated dippers containing 9 g of bait. One dipper of bait was scattered near each active burrow opening. Only one bait application was made.

Bait Acceptance Test - On a nearby, but separate area a comparative bait acceptance test was conducted. The acceptance by squirrels of the test bait and three untreated grains (squirreled oat groats, whole oats and whole steam-rolled oats flavored with molasses) was compared. In an active squirrel colony 5 grams of each bait was placed near an active burrow opening within a 6 inch diameter spot. Only one type of bait was placed by a burrow opening. Each bait spot was at least 25 feet apart. Twenty bait spots per grain type were placed. Percent consumption of each bait spot was estimated visually.

Efficacy Determination - Efficacy was determined using three methods.

1. Visual counts. Activity indices were generated using visual counts. Visual counts consisted of 3 counts, at 5 minute intervals, each day for 3 consecutive days. Counts were conducted the week before treatment and 14 and 28 days after treatment. Percent reduction in activity was calculated using the following formula:

$$\text{Percent Reduction in Activity} = 1 - \frac{\text{No. Squirrels Counted Posttreatment (Treated Plot)} \times \text{No. Squirrels Counted Pretreatment (Control Plot)}}{\text{No. Squirrels Counted Pretreatment (Treated Plot)} \times \text{No. Squirrels Counted Posttreatment (Control Plot)}} \times 100$$

2. Active Burrow Counts. Efficacy was determined by calculating the reduction in active burrows. At least 50 active burrows per plot were flagged and closed with soil before and after treatment on each plot. The number of burrows reopened was counted 2 days after closure. Pretreatment closures were done 3 days prior to bait application. Posttreatment burrow closures were conducted 14 and 28 days after treatment using the same burrows closed before treatment.

Precent reduction in active burrows were calculated using the following formula:

$$\text{Percent Reduction in Active Burrows} = 1 - \frac{\text{Holes Reopened Posttreatment (Treatment Plot)} \times \text{Holes Reopened Pretreatment (Control Plot)}}{\text{Holes Reopened Pretreatment (Treatment Plot)} \times \text{Holes Reopened Posttreatment (Control Plot)}} \times 100$$

3. Radio-tagging. Twenty ground squirrels on the treatment plot were livetrapped in traps baited with whole, steam rolled oats flavored with molasses. Each squirrel was weighed, sexed, fitted with a radio transmitter and released at the point of capture. Two squirrels were fitted with transmitters 11 days before bait application to test telemetry equipment under field conditions. The rest of the squirrels were radio-equipped 2 days before baiting. Efficacy was determined using the following formula:

$$\text{Efficacy of Bromadiolone Treatment} = 1 - \frac{\text{No. Squirrels Radio-tagged} - \text{No. Radio-tagged Squirrels Found Dead}}{\text{No. Squirrels Radio-tagged}} \times 100$$

A separate ground squirrel colony was used as a control plot for visual and active burrow counts. No bait was applied to the control plot nor were any squirrels radio-tagged.

Radio Telemetry - Telemetry was used to determine the fate of ground squirrels and track their movements on the study area. Radio collars were constucted from commercially available components (AVM Instrument Co.). The transmitter unit was attached to a nylon wire tie which formed the collar. Completed units weighed about 8 g and were attached to animals weighing 310 g to 900 g. Each unit had a 6 inch whip antenna and had an above ground range of about 0.4 mile. Twenty frequencies within the 148 MHz range were used. The minimum interval between frequencies was 25 Hz.

Radio-equipped ground squirrels were located with a portable AVM LA-12 receiver and a 3 element yagi antenna. Locations were recorded by compass bearing and paced distances from numbered flags on the plot borders.

Ground Squirrel Recovery - Ground squirrels found dead on the ground surface were recovered immediately. Ground squirrels that died under ground were excavated as soon as repeated transmitter locations indicated no movement and probable death. Squirrels found moribund were killed with CO_2 gas. Squirrels that survived the rodenticide treatment were killed by burrow fumigation (gas cartridge, EPA Reg. No. 6704-4; Pocatello Supply Depot, Pocatello, ID) and excavated. Recovered carcasses were weighed, checked for external symptoms of anticoagulant poisoning and frozen individually in plastic bags.

RESULTS AND DISCUSSION

The four baits tested for bait acceptance were readily and equally consumed by ground squirrels. All placements of each test bait were consumed within 10 hours during the first day of placement.

The bromadiolone bait placed on the treatment plot was consumed over a 2.5 day period. One day after bait application about 20 percent of the bait had been consumed. Few bait spots were completely eaten. Many bait spots were untouched or showed only minor consumption. After 2 days less than 50 percent of the bait was consumed although most bait spots showed partial consumption or investigation of the bait. On the afternoon of the second day 0.23 inches rain fell on the study area between 1900 and 2100. Between 0900 and 1700 on the third day the remaining bait was eaten.

The reason for the slow consumption of the test bait is unclear, particularly in light of the results of the comparative bait acceptance test. Squirrels were accustomed to and readily accepting the oats used for baiting livetraps. However, 2 to 3 days were required after initial bait and trap placement before all newly placed bait was eaten within one day. Squirrels were also foraging on seeds being produced by plants on the plot. Disturbance of the study area during the time that bait was available was minimized. On the day of bait application the plot was undisturbed after baiting was completed. Slow consumption of the test bait may have been a neophobic response by the squirrels to the test bait. It may have been sufficiently different from the livetrap bait to cause an avoidance response by being something new and unfamiliar in their environment.

Four of the 20 radio-equipped squirrels did not die as a result of the bait treatment. One squirrel (65-300, Table 1) died as a road-kill or from predation before treatment. Two squirrels (71-452, 78-625) were off the study plot when bait was available and were not believed to have been exposed to the bait. One of these squirrels was recovered after burrow fumigation and the transmitter signal was lost from the second squirrel. The regular movement of these squirrels well after the death of the others indicated that they were not experiencing symptoms of anticoagulant poisoning. The fourth squirrel (76-601), a large, 900 g male, was on the plot when bait was present but remained active 14 days posttreatment and did not exhibit symptoms of anticoagulant poisoning. This squirrel was recovered by excavation after burrow fumigation. The carcasses of the two squirrels recovered showed no external signs of anticoagulant poisoning.

Three (63-253, 66-328, 69-400) of the remaining 16 radio-equipped squirrels were moribund when recovered. Since their recovery seemed unlikely they were killed with CO_2 gas and were counted as bait mortalities. The signal of one squirrel (61-171) was lost and its fate was not determined. Telemetry locations prior to

TABLE 1. Weight change and number of days to death for Columbian ground squirrels treated with bromadiolone bait.

Squirrel No.	Sex	WT(g) Capture/Death	Wt Change g / %	DAYS: Death or No Movement	DAYS: Carcass Recovery
57-048	M	575 / 457	-118 /-20.5%	6	9, excavated
58-072	M	710 / 732	+22*/+ 3.1%	5	7, excavated
59-097	M	500 / 546	+46*/+ 9.2%	5	7, excavated
60-150	M	750 / 803	+53 /+ 7.1%	4	4, surface
61-171	F	590 /		6	signal lost day 8
62-227	F	660 / 647	-13 /- 2.0%	5	5, surface
63-253	M	800 / 722	-78 /- 9.8%	7	7, surf/morib.
64-278	F	480 / 470	-10 /- 2.1%	6	6, surface
65-300	M	380 /			Death, pretreatment
66-328	F	530 / 477	-53 /-10.0%	6	8, excv/morib.
67-351	F	570 / 564	-6 /- 1.1%	5	9, excavated
68-375	M	380 / 309	-71 /-18.7%	6	9, excavated
69-400	F	500 / 473	-27 /- 5.4%	5	7,excv/morib.
71-452**	M	480 /			Signal lost day 14
72-501	F	460 / 460	0 / 0	4	4, surface
74-552	F	480 / 459	-21 /- 4.4%	6	9, excavated
75-578	M	500 / 443	-57 /-11.4%	8	9, excavated
76-601	M	900 / 900	0 / 0		Fumigation day 14
78-625**	M	310 / 371	+61 /+19.7%		Fumigation day 13
79-651	M	370 / 339	-31 /- 8.4%	5	5, surface

* Radio-tagged 9 days before other squirrels, 11 days before treatment.
** Squirrels not exposed to bait.

signal loss remained unchanged for 1.5 days. The squirrel was probably moribund and it was classified as a bait mortality. Excavation of the site of the last signal locations failed to find the squirrel or transmitter.

Death of 16 of 17 radio-tagged squirrels exposed to the test bait resulted in a 94.1 percent mortality. Squirrel activity on the treatment plot was reduced 100 percent 14 days after treatment based on both visual counts and active burrow counts. At 28 days after treatment reduction was 97.5 percent using active burrow counts and 88.2 percent based on visual counts.

The consumption of the test bait over a 2.5 day period may have enhanced the efficacy of the bait. The same dose of an anitcoagulant may be fatal when ingested by multiple feedings but may produce little or no effect when eaten in one feeding (Timm 1983). If the test bait had been consumed entirely on the day of application, efficacy may have been reduced.

In a single dose feeding study using bromadiolone bait, Sullivan (1982b) found that some Columbian ground squirrels survived doses of 2 mg/kg although none survived a dose of 2.1 mg/kg or greater. The minimum dose observed to cause death was 0.36 mg/kg with an average fatal dose of 1.09 mg/kg for squirrels that died from doses less than 2 mg/kg. In this study, squirrels weighing 437 g or more might have survived the bait application if they had eaten 9 g of bait or less the day of application and ate no additional bait. (Consumption of 0.9 mg bromadiolone contained in 9 g of 100 ppm bait by a 437 g squirrel is equivalent to 2 mg/kg.) In this study, 16 of the radio-equipped squirrels weighed more than 437 g (range 480 g to 900 g).

The average number of days to death or cessation of movement for the 16 squirrels that died from the bait application was 5.5 days (range 4 - 8). Six (35.3%) of the 17 squirrels exposed to the bait died above ground. All six were found in the burrow entrance, facing outward, or within 3 feet of a burrow opening. One of the squirrels found above ground was moribund. The average percent weight loss for recovered squirrels that died from the bait application was 6.6 percent (range 0 - 20%).

One unmarked squirrel was found dead at a burrow opening. No other target or nontarget carcasses were found on the treatment plot during twice daily monitoring of the area. No potential scavengers or predators or their sign were observed on the study site.

Results of carcass residue analyses were not available at the time this report was completed.

Telemetry tracking of radio-equipped squirrels permitted estimation of home range for these squirrels before onset of poisoning symptoms or death. Male squirrels had an average home range size of 1.22 acres while females averaged 0.20 acres (Table 2). Similar home range size was found for Columbian ground squirrels in southwestern Alberta by Murie and Harris

TABLE 2. Estimated home range size and range of movement of radio-equipped Columbian ground squirrels.

MALES						FEMALES					
Squirrel No.	WT(g)	Feet			Area (acres)	Squirrel No.	Wt(g)	Feet			Area (acres)
		Ave	Max1	Max2				Ave	Max1	Max2	
57-048	575	141	280	328	0.44	61-171	590	76	128	144	0.16
58-072	710	189	432	784	1.67	62-227	660	118	296	320	0.17
59-097	500	180	392	544	1.63	64-278	480	48	72	80	0.033
60-150	750	244	368	592	0.92	66-328	530	52	184	184	0.19
63-253	800	133	208	352	0.54	67-351	570	46	72	72	0.062
68-375	380	56	128	136	0.095	69-400	500	151	216	224	0.42
71-452	480	66	288	320	0.44	72-501	460	80	192	192	0.10
75-578	500	108	360	592	1.40	74-552	480	107	336	336	0.47
76-601	900	129	544	928	3.36						
78-625	310	206	680	680	2.26						
79-651	370	124	248	264	0.65						
AVERAGE		143	357	502	1.22			85	187	194	0.20

Ave - Average distance between successive locations.
Max1 - The longest distance between successive locations.
Max2 - The longest home range dimension.

(1978, males - 1.04 acres) and Festa-Bianchet and Boag (1982, females - 0.25 acres).

The longest dimension of the males' home range averaged 502 feet with 928 feet being the longest dimension recorded. For females the average for the longest home range dimension was 187 feet with a maximum of 194 feet. Several squirrels ranged off the treated area. The longest movements from the edge of the treated area were 350 and 450 feet recorded for two male squirrels. One of these squirrels, a juvenile, crossed the adjacent interstate highway several times.

The treatment of a buffer zone around the immediate control site is a standard management recommendation to slow reoccupation of the protected area by neighboring ground squirrels. The range movements observed by the squirrels in this study support the use of treated buffers as a sound management technique.

RECOMMENDATIONS

The use of a single study plot was valuable for gauging the efficacy potential of the test bait. Confirmation of the efficacy results by conducting 3 to 5 replications is needed. Additional replications will also expand the data on the ratio of above and below ground deaths, time of death, home range size and carcass residue levels.

When ground squirrels are managed with single dose rodenticides consumption of the bait within 24 hours or less is desired. This reduces the possibility of bait degradation by unpredictable weather and the time bait is exposed to nontarget animals is also reduced. Multiple feedings on the bait by the squirrels may have produced better efficacy than if the bait had been eaten in a single feeding. Additional replications of this study with a modified study design to enhance bait acceptance or reduce possible bait avoidance needs to be conducted to resolve this question.

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